

appropriate enzymes for the oxidation of the compound. A sufficient supply of other nutrients and a terminal electron acceptor are also required.

The *principle of microbial infallibility* informally refers to the idea that given a supply of potential food, microbial communities will develop the metabolic capability to use that food for biochemical energy. Not all degradation reactions, however, involve the oxidation of SOC. Some of the most problematic organic contaminants are chlorinated compounds.

Chlorinated SOC do not exist naturally, so microbial systems generally are not adapted for their degradation. Chlorine is an extremely electronegative element. The electronegativity of chlorine refers to its penchant for sucking on electrons. This tendency explains why chloride exists as an anion and why an attached chloride diminishes the solubility of an aromatic ring. Given this character, it is difficult for biological systems to oxidize chlorinated compounds. An initial step in that degradation, therefore, is often reductive dechlorination. The chlorine is removed by reducing the compound (i.e., by giving it electrons). After the chlorines are removed, degradation may proceed along oxidative pathways. The degradation of chlorinated SOC thus may require a sequence of reducing and oxidizing environments, which water may experience as it moves between stream and hyporheic zones.

The overall degradation of SOC often follows complex pathways. **Figure 2.29** shows a complex web of metabolic reaction for a single parent pesticide. Hydrolysis, reduction, and oxidation are all involved in the degradation of SOC, and the distribution and behavior of degradation products can be extremely variable in space and time.

Chemical consequences are rarely the immediate goal of most restoration actions. Plans that alter chemical processes and attributes are usually focused on changing the physical and biological characteristics that are vital to the restoration goals.

Toxic Concentrations of Bioavailable Metals

A variety of naturally occurring metals, ranging from arsenic to zinc, have been established to be toxic to various forms of aquatic life when present in sufficient concentrations. A primary mechanism for water column toxicity of most metals is adsorption at the gill surface. While some studies indicate that particulate metals may contribute to toxicity, perhaps because of factors such as desorption at the gill surface, the dissolved metal concentration most closely approximates the fraction of metal in the water column that is bioavailable. Accordingly, current EPA policy is that dissolved metal concentrations should be used to set and measure compliance with water quality standards (40 CFR 22228-22236, May 4, 1995). For most metals, the dissolved fraction is equivalent to the inorganic ionic fraction. For certain metals, most notably mercury, the dissolved fraction also may include the metal complexed with organic binding agents (e.g., methyl mercury, which can be produced in sediments by sulfate-reducing bacteria, is soluble and highly toxic, and can accumulate through the food chain).

Toxic Concentrations of Bioavailable Metals Across the Stream Corridor

Unlike synthetic organic compounds, toxic metals are naturally occurring. In common with synthetic organics, metals may be loaded to waterbodies from both point and nonpoint sources. Pollutants such as copper, zinc, and lead